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CALIFORNIA ENERGY FLOW IN 1992

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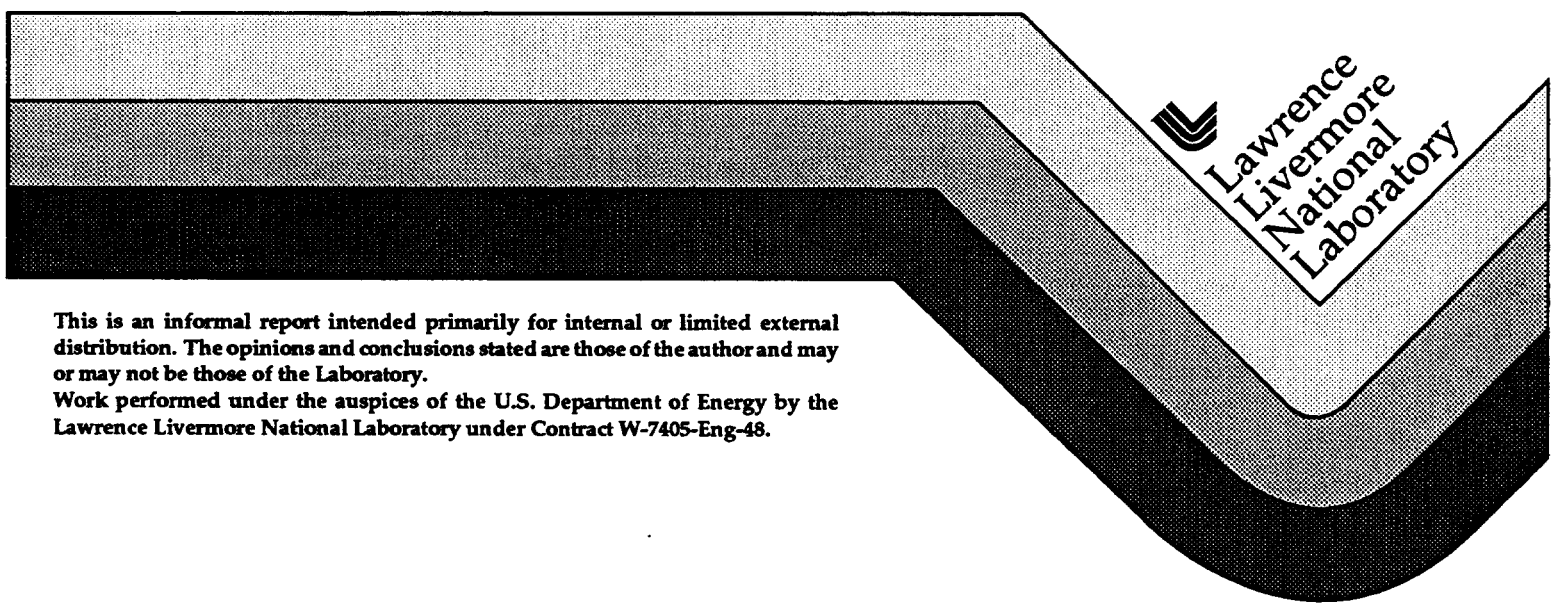

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DISCLAIMER

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ABSTRACT

In 1992 energy consumption in California moved up slightly despite a continuing statewide recession marked by an unemployment rate of almost 10% at year's end. Nonetheless industrial energy consumption increased reflecting increased use of fossil fuels in enhanced oil recovery and cogeneration. A small drop in residential/commercial energy consumption related to an uncommonly mild winter. Energy use in the transportation sector declined for the second year reflecting most importantly a 30% decline in the sale of bunkering fuels at California ports due to the imposition of new taxes in 1991 and a 2% fall in gasoline sales between 1991 and 1992.

Oil production in the State remained at 1990-1991 levels. Increased federal offshore production notably at the Point Arguello field countered declines in onshore areas. Gas production fell, and an increased demand was satisfied by greater imports from the Southwest U.S., Rocky Mountain area and Canada. Gas pipeline construction continued at a record pace with the completion of five pipelines into the state.

Electricity demand increased and was met by increased generation from natural gas made possible by the pipeline completions and by greater output from the State's nuclear power plants. The latter occurred despite the retirement of the State's oldest nuclear reactor, San Onofre Unit 1 (436 MWe) in San Diego County. Collective electricity generated at California's many geothermal fields remained at the previous year's level although output at The Geysers, the world's largest field continued to decline. Contributions from windpower to electrical demand fell for the first time since 1983 due in part to expiration of long-term, "standard offer" contracts with favorable rates that had been negotiated with the utilities purchasing the power. Electricity from windpower made up a little more than 1% of power transmitted by the utilities to users. Solar energy's contribution to the energy slate is largely in the form of hot water and is not accurately monitored. The only sizable solar electrical installations are experimental in nature and make a negligible contribution.

INTRODUCTION

For the past 16 years energy flow diagrams for the State of California have been prepared from available data by members of the Lawrence Livermore National Laboratory.[1] They have proven to be useful tools in graphically expressing energy supply and use in the State as well as illustrating the difference between particular years and between the State and the U.S. as a whole.

As far as is possible, similar data sources have been used to prepare the diagrams from year to year and identical assumptions[1a-1e] concerning conversion efficiencies have been made in order to minimize inconsistencies in the data and analyses. Sources of data used in this report are given in Appendix B and C; unavoidably the sources used over the 1976-1993 period have varied as some data bases are no longer available. In addition, we continue to see differences in specific data

CALIFORNIA ENERGY FLOW -1992
TOTAL CONSUMPTION 6900 × 10^{12} Btu

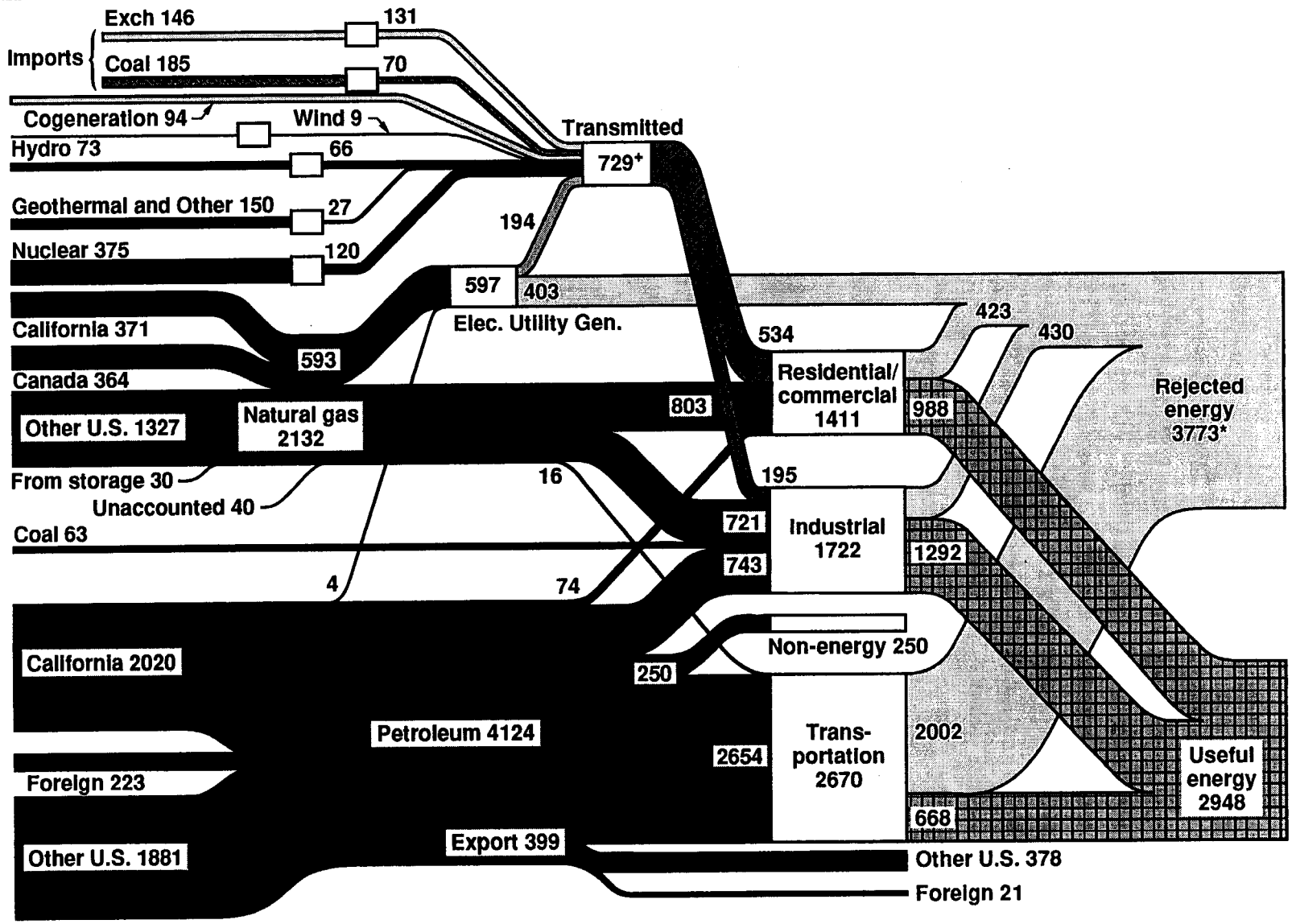

Figure 1

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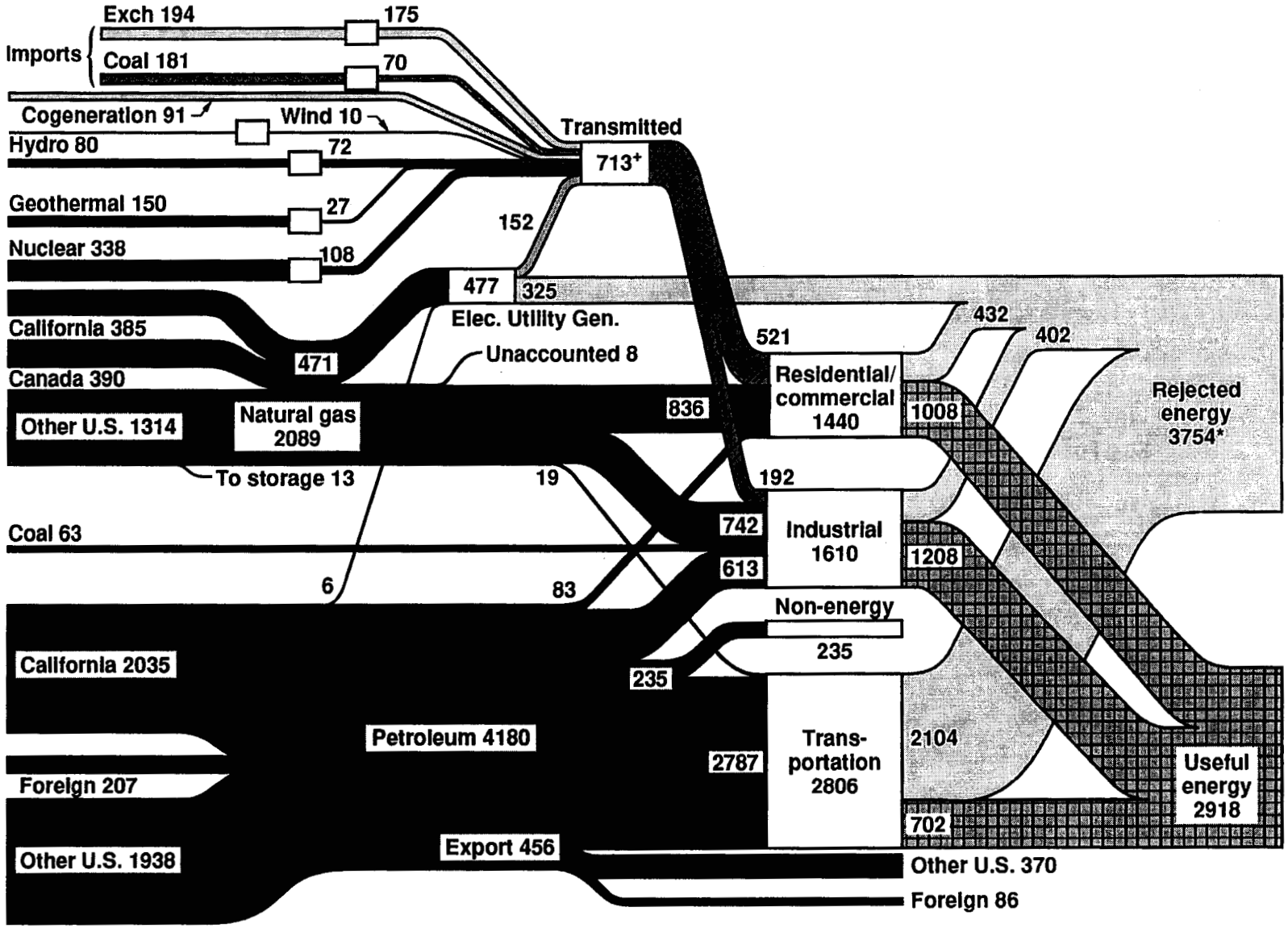
CAL ENERGY FLOW 92 preliminary

+ Includes 18 units from miscellaneous sources
* Includes rejected energy for hydro, coal, geothermal, and nuclear conversions

CALIFORNIA ENERGY FLOW -1991
TOTAL CONSUMPTION 6800 × 10^{12} Btu



+ Includes 8 units from miscellaneous sources

* Includes rejected energy for hydro, coal, geothermal, and nuclear conversions

I. Borg / C. Briggs
CAL ENERGY FLOW 91 revised
3/94

Figure 2

U.S. Energy Flow – 1992
Net Primary Resource Consumption 82 Quads

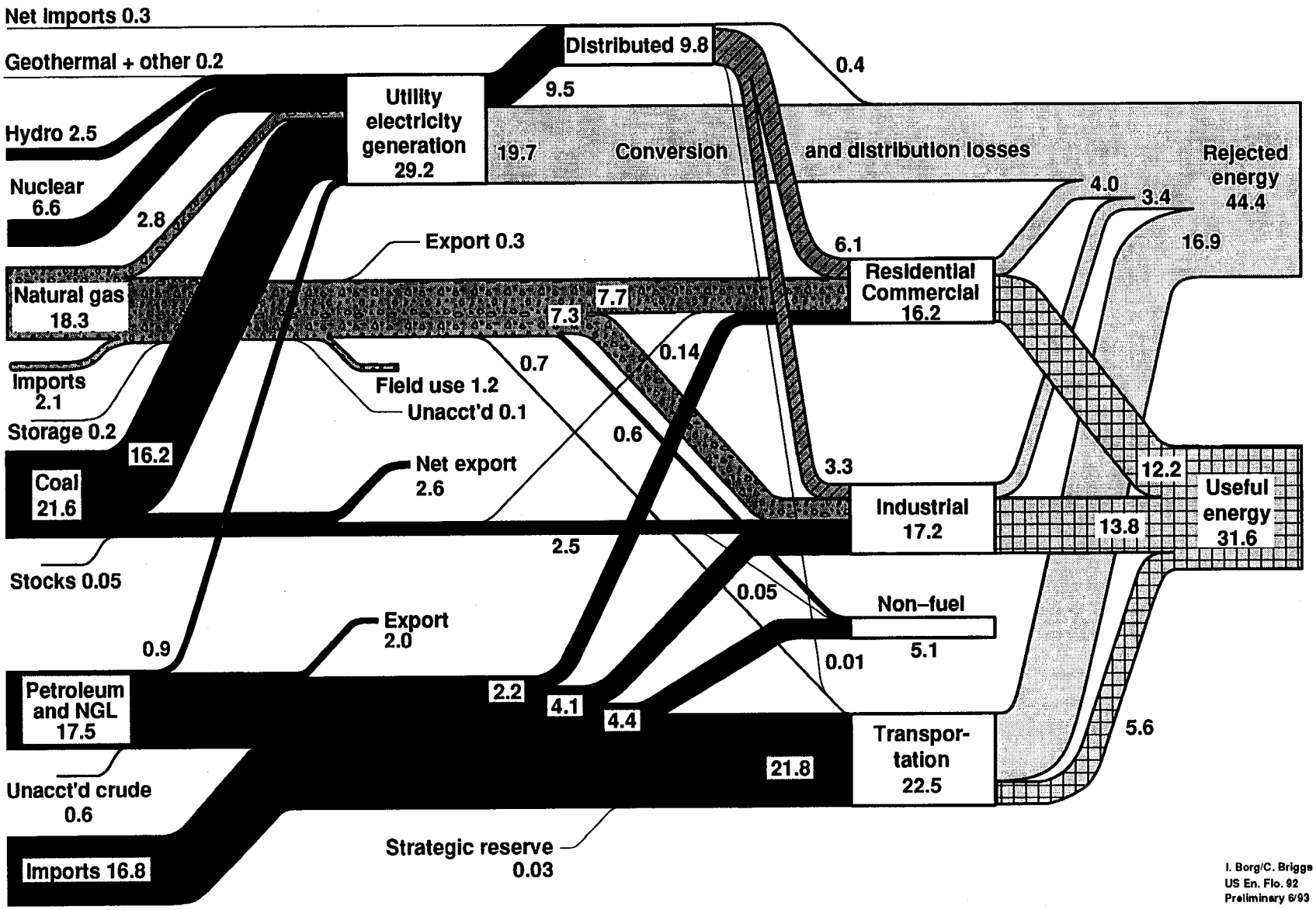


Figure 3
(Quad at 10^{15} BTU)

desirable to express as closely as possible the energy content of the sources used during the year. In this way it is possible to see at a glance which energy sectors are associated with the greatest conversion losses and thus the largest targets for potential technological improvements in conversion efficiencies.

Power from cogenerators and self-generators sold to utilities are shown in the figures as inputs to total transmitted electricity and appear without a box (representing the conversion process) that ordinarily would appear between the energy content of the fuel and the final product. In this instance, conversion losses are included in "rejected energy" from the industrial sector. Not shown in the flow diagrams is the amount of electricity used "in house" by the cogenerators. The amount of electricity consumed by the industrial sector, 195 x 10^{12} Btu in Fig. 1, represents purchases from the utilities only.

CALIFORNIA'S ENERGY FLOW IN 1992 COMPARED TO 1991

The Economy

While the economy of the nation apart from California showed signs of recovery from the worst recession since the 1930's, California's economy continued to decline in 1992 (Table 1). Most noteworthy was the unemployment rate that stood at 9.8% at year's end as compared to 6.9% for the rest of the nation.[3] This is in marked contrast to California's economic performance between the end of World War II and 1989 when it consistently out performed the rest of the nation. Explanations for change include continued cutbacks in defense expenditures in the State, the five year drought, tax increases and state expenditure cutbacks and over expansion of the commercial construction industry.[4] Unique impacts on California's economy in 1992 include a

Table 1.

Selected economic data for California — 1992[5]

Indicator	Percent change from 1991
Unemployment	+23.1
Civilian employment	0.6
Housing units authorized	-9.9
New auto registrations	-6.7
Total taxable sales	0.8
Corporate profits before taxes	+8.2
Personal income	+2.6
Consumer price index	+3.5

series of large earthquakes (Palm Springs in April, Ferndale in April and Yucca Valley/Big Bear in June) and the Los Angeles riots at the end of April, which were all disruptive of normal economic activity.

The construction industry continued to languish (Table 2) as evidenced by the decrease for the fourth year in the number of authorizations for construction of new multiple residential, commercial and industrial units. The situation would be worse if it were not for the rebuilding in the San Francisco Bay Area following the Montclair district fire in 1991 and Loma Prieta earthquake in 1989.

Table 2

Construction authorized by permit — 1992[6]

Value in Millions of Dollars

Year	Residential	Nonresidential	
		Commercial	Other*
1988	26,361	6,569	7,592
1989	27,790	6,159	7,507
1990	20,686	5,270	7,466
1991	15,056	3,374	6,247
1992	14,451	2,472	5,683

*Other consists of all other categories including additions and alterations of $100,000 or more.

Energy Consumption

Use of energy in California for the preceding decade is summarized in Table 3. In 1992 crude oil continued to be the principal source of supply with about half of it coming from out-of-state sources. Demand was close to 1991 levels. Natural gas was the next most important fuel with more than three-quarters of the supply being imported. Use rose slightly in 1992 principally because of increased use for utility electricity generation. However the largest single source of transmitted electricity was imports from other states.

There was a small drop in residential/commercial energy use which relates to an uncommonly mild winter experienced in all parts of the state (Table 4). Although electricity use rose slightly, it was more than compensated by a decrease in consumption of natural gas, the principal fuel used for space heating. Industrial activity as measured by energy consumption increased in 1992 as did the "non-energy" component. The "non-energy" component of industrial

Table 3

Comparison of Annual Energy Use in California

(in 10^{12} Btu)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Natural Gas	893	1769	1865	2034	1697	2091	1932	2087	2069	2089	2132
Crude Oil (less exports)	3327	3329	3477	3580	3601	3591	3899	4015	3884	3736	3725
Transmitted Electricity	642	622	700	673	697	718	744	757	763	713	729
Residential/Commercial	1225	1268	1176	1325	1224	1325	1350	1403	1474	1442	1411
Industrial	1570	1395	1493	1648	1456	1439	1557	1646	1560	1616	1722
Non-energy	158	183	221	185	203	292	235	237	252	245	250
Transportation	2265	2313	2464	2384	2499	2564	2715	2781	2817	2800	2670
Total Energy Consumption†	6000	5900	6200	6400	6200	6600	6750	6950	6900	6800	6900

† Total is not sum of above figures because of rounding and inclusion of losses associated with conversion to electrical energy.

Table 4
Weather Comparison
1968 - 1992
Annual Heating Degree Days**

	San Francisco Federal Office Building	Los Angeles Civic Center	San Diego Lindbergh Field
1968	2942	850	1052
1969	3066	1032	1145
1970	3006	941	1137
1971	3468	1424	1657
1972	3240	918	1166
1973	3161	1066	1137
1974	3182	1084	1123
1975	3313	1548	1416
1976	2665	1128	793
1977	2888	911	747
1978	2599	1208	736
1979	2545	1160	902
1980	2799	597	590
1981	2819	506	573
1982	3195	975	913
1983	2386	602	623
1984	2648*	704	713
1985	2486*	921	1079
1986	1842*	473	843
1987	2150*	979	1201
1988	2194*	867	1102
1989	2526*	844	1068
1990	2340*	839	1172
1991	2422*	879	1212
1992	1718	705	866
Normal 1951-80	2750***	1204	1284

* CA. Mission Dolores same historical data as for Federal Office Building

Source: Local Climatological Data for San Francisco, Los Angeles and San Diego, National Oceanic and Atmospheric Admin., National Climatic Data, Asheville, NC.

** A "degree day" is a term that describes the relationship of energy consumption to outdoor temperatures. "Heating or cooling degree days" are deviations of the mean daily temperature from 65°F. For example for a day with a mean temperature of 40°F, the "heating degree days" would be 25 and the "cooling degree days" 0. Annual heating degree days are the sum for the year. Greater number of heating degree days means greater fuel requirements.

*** Revised by W. J. Koss, NOAA, September 7, 1988.

consumption consists of fuels used to produce products such as petrochemicals, fertilizers, waxes, lubricating oils, asphalt etc. These products are not burned to produce energy.

TRANSPORTATION FUELS

Consumption

Transportation use of fossil fuels fell substantially for the first time in seven years (Table 3). The decrease can be traced to (1) continued and marked drop in sales of bunkering fuels at California ports and (2) a drop in gasoline consumption (Table 5). Sales of bunkering fuels have been affected by new taxes imposed in mid-1991. The decline in gasoline sales is a reflection on improved fuel economy of highway vehicles and the recession, which hampered commercial business activity and reduced the number of registered commercial vehicles.[7] Nonetheless the estimated vehicle miles of travel on California State highways rose 1.44% and 75,000 new drivers

Table 5
California Transportation End Use
(in 10^{12} Btu)

	1986	1987	1988	1989	1990	1991	1992
Net gasoline*	1543	1576	1612	1630	1664	1712	1670
Net aviation fuel	392	390	427	458	475	476	473
Taxable diesel fuel -public highways	218	174	244	265	253	246	256
Rail diesel	31	30	26	30	31	33	30
Net bunkering fuel	267	347	357	348	344	288	202
Military	35	28	29	30	29	26	23
Natural gas-pipeline fuel	15	13	20	20	21	19	16
Natural gas vehicular	–	–	–	–	0.004	0.01	0.03
Total**	2499	2565	2715	2781	2817	2800	2670

* As of January 1, 1992 leaded gas was no longer produced at California refineries.
** Some electricity is used for mass transit; however the amount is not monitored on a state-wide basis and hence does not appear in this table or in Figs. 1 and 2.
Source: Fuel and Kerosene Sales, DOE/EIA, 1992; Quarterly Oil Report, Fourth Quarter 92 (Net gasoline and aviation fuel), California Energy Commission, Sacramento, CA; Natural Gas Annual-1992, DOE/EIA-0131(92) Table 48, Department of Energy, Washington, DC (November 1993).

licenses were issued.[7] Intercity bus travel was down for the third straight year as was transit patronage reported by the 11 major transit operators in the state. Intercity and commuter rail systems reported mixed results for the year.

Automobile Emission Standards

The California Air Resources Board (CARB) has set the toughest regulations in the nation under the Clean Air Act of 1970 and its amendments. The act restricted the independent action of all states without Environmental Protection Agency's (EPA) approval. Because California had an active emission abatement program, it was able to continue to write its own rules; however, for the first time since the passage of the Act, it had to have permission to enforce them. Applications to the EPA for the so-called "waivers" have been met with little opposition through the years and led to now common items as catalytic converters and no-lead gasoline requirements ultimately applied nationally by EPA.

In 1992 for the first time EPA looked hard at some of the regulations passed by CARB in 1990.[8] In particular, the Low-Emission Vehicle Program, which proposes that 1994 to 2003 models run 60-85% cleaner than current models and that 2-10% be "zero polluting" between 1998 and 2003, has come under attack from both car manufacturers and refiners. Strangely, the problem is that other states have either already adopted the program or are about to. While California represents only about a tenth of the nation's car market, a program embracing many states could seriously impact the nation's ailing car industry. A General Motors spokesman claimed that the company might survive having to recall every car built in California for failing to meet emission requirements, but it could not survive a national recall. Both the car manufacturers and refiners point out that severe air pollution is California's problem and not that of every state. They point out that pollution in the State is driven by a car population that is growing twice as fast as its human population.[9] Further the oldest cars in the nation use its highways. Nearly one-third are pre-1979 models which are heavy air polluters.[8] Old cars may account for only about a fifth of the miles driven in the state but nearly 60% of the hydrocarbons and about half of the carbon monoxide and nitrogen oxides according to CARB. Hence they suggest among other things a more aggressive program to maintain and/or retire this old fleet of vehicles.

Because California has indicated that it wants 2% of new cars sold in the state in 1998 to be non-polluting and because at least nine other states have said they will concur, all auto makers have embarked on programs to develop electric vehicles. In addition, a consortium of public and private California interests called Calstart unveiled a prototype in 1992. To some an electric car industry in California would be a suitable substitute for the declining defense and aerospace industries of the State. This remains wishful thinking until technical "break-throughs" in battery or fuel cell technology are realized. Because the current vehicles have limited range, they are believed to have little customer appeal. Assuming gasoline prices do not escalate to high levels in the next decade, it is likely that the consumer rather than the regulator will decide the issue in the long run. In the meantime several public utilities and public agencies are taking appropriate steps to assist the hoped for transition to non polluting vehicles. For example, through the decisions of the California Public

Utilities Commission, legislative mandates, and utility initiatives, $50 million for "low emission vehicle" research and activities is paid annually by California utility rate payers.[10]

OIL AND GAS PRODUCTION

Oil Production

California oil production remained at 1990 and 1991 levels and thus was down about 18% from the all time high recorded in 1985.[11] Declines registered in state onshore and offshore fields were compensated by an increase in federal offshore production. Again the Midway-Sunset oil field was the largest producing field in the U.S. outside of Alaska. It reached its all-time high production rate in June 1992; its cumulative production over its 100 year lifetime is well over two billion barrels.

Enhanced oil recovery accounted for about 61% of California's total oil production.[11] Steam stimulation was credited with about 80% of all incremental oil production and water flooding the remainder.

The number of new oil, gas, service and exploratory wells drilled onshore or in California offshore provinces fell 46% in 1992.[11] The 1212 wells drilled are about a third of the all time high recorded in 1985 and somewhat below 1960 totals.

A ten year dispute between Chevron and officials of Santa Barbara County concerning the way to move crude oil from the Point Arguello offshore field to shore, reached an interim resolution. Santa Barbara officials' concern centered on potential oil spills from tankers. Heretofore most of the production was piped to Chevron's Northern California refinery where it was loaded onto tankers destined for Southern California— ironically transiting the Santa Barbara County coast line. Limited pipeline capacity had curtailed production at the field. The compromise calls for crude not accommodated by existing pipelines to be tankered directly to Southern California refineries.[12] The tankering must end by January 1996 when construction of additional pipelines are completed. The consequence of the compromise was that output from the field increased from 65,00 barrels a day to 90,000 barrels a day making it the largest producer in both state and federal waters off California.

Ten companies shipping oil from Alaska to California ports agreed to stay at least 50 nautical miles from the California mainland.[13] As almost all of California's imported oil comes from Alaska (Fig. 1) about 85% of all arriving oil tankers will be covered by the voluntary agreement. The 50 mile minimum distance was arrived at after a review of studies of oil spills, present vessel routes and consultation with California's Department of Fish and Game's Office of Oil Spill Prevention and Response.

As another indication of continued concern over oil spills in offshore provinces, Governor Wilson signed legislation banning offshore drilling in state waters from San Simeon to the Oregon border.[14] Together with Presidents Bush's ban on oil and gas lease sales in federal waters off California, Governor Wilson's action effectively bans further activity until after 1995. Similar bans are already in place in the southern part of the state.

Natural Gas Production

Gas production fell 8% from 1991 levels with the greatest decrease registered by so called "non associated" wells, i.e. wells not associated with oil production.[11] Natural gas production in the state is divided approximately equally between the two types of wells with "associated" production occurring predominantly in the southern part of the State and "non associated" production in the northern.

NATURAL GAS SUPPLY

Natural gas production in the State has fallen to about half of its historic high of 1966-68. The decline and growing demand for the fuel has resulted in increased out-of-state imports. In 1992 they comprised 79% of demand — 62% from the Southwest U.S. and 17% from Canada (Fig. 1).

Gas pipeline construction in California continued at a record pace (Table 6) with the completion of five lines into the state from the Southwest U.S. or Rocky Mountain area. The Kern River Gas pipeline, the biggest built in the U.S. in the last decade, was dedicated in the Spring. The capacity of the 904 mile pipeline is currently 700 Mcf/d, and it can be boosted 452 Mcf/d by adding compressors.[15] The Kern River pipeline is California's only direct link to Rocky Mountain gas reserves. With the completion of Pacific Transmission Company's 805 mile line from Canada in November of 1993, pipeline capacity into the state will have increased 46% since 1990.[16] A large part of the new capacity is directed to enhanced oil recovery operations in the heavy oil fields in Southern California where air quality regulations have made natural gas the only acceptable fuel to raise steam in underground steam flooding operations. This demand has led to a steady increase in industrial natural gas consumption in the State.

Table 6

Status of California Pipeline Proposals 1992[16]

Project	Miles	Capacity (Bcf/d)
Completed or under construction	2475	3.143
Proposed or pending	1013	2.606
Total	3488	5.749

The second most important destination for the additional gas is electrical generating facilities belonging both to utilities and cogenerators. Again air quality considerations and high costs associated with nuclear power plants make natural gas the fuel of choice in new facilities.

For several years the California Public Utilities Commission has tried to force the state's utilities to buy natural gas from Canadian suppliers on short-term contracts in order to reduce costs to consumers. Heretofore the utilities have routinely paid a premium for the security of supply associated with long-term contracts. In 1992 the Canadian National Energy Board became concerned when California utilities began to negotiate short term contracts, and it stepped in by prohibiting new exports of natural gas to northern California.[17] The intent was to pressure the utilities to meet their long-term contracts to buy natural gas instead of switching to cheaper short term supplies.

ELECTRIC POWER

Source of Supply

The most noteworthy change in California's electrical supply in 1992 was the increase in the use of natural gas for power production and the commensurate decrease in the amount of purchases from the Pacific Northwest (Table 7). New gas pipelines into the state are making such a switch possible. Also noteworthy was a 10% increase in the contribution made by nuclear power.

Total utility generating capacity (Table 8) was very near 1991's. There were small increases in natural gas, hydropower and alternative fuel capacity which together countered a decrease in nuclear capacity.

Table 7

Sources of California Utilities' Electricity — 1992

Source	Net electrical energy (trillion Btu)	
Imports		201
Out-of-state coal facilities	70	
Purchases	131	
Fossil fuels		194
Natural gas	193	
Oil	1	
Nuclear power		120
Hydropower		66
Geothermal power		27
Windpower		9
Cogeneration		94
Miscellaneous		18
TOTAL		729

Table 8
California Utility Electrical Generating Capacity[18]

Primary energy source	Capacity (GWe)
Petroleum	2.16
Gas	21.97
Water	13.17
Nuclear	4.31
Other (principally geothermal)	2.16
TOTAL	43.77

* Summer capability as of December 31, 1992

Properly added to the utility generating capacity of Table 8 is the combined capacity of nonutility generating facilities which in 1990 was about 9.3 GWe[19] and about 11 GWe[20] in 1992. Nonutility generators are self-generators or cogenerators, most of whom are qualified facilities under the Public Utility Regulatory Policies Act of 1978 (PURPA). As such the utilities are required to purchase their output at the utility's "avoided cost", which is the incremental cost that an electric utility would incur to produce or purchase an amount of power equivalent to that purchased from the qualified facilities. Additionally, these facilities are guaranteed back up service from the electric utilities at non-discriminatory rates. Of the 59 billion kWh generated by the group of nonutilities in 1992, 78% was sold to utilities or other nonutilities; the remainder was used by the generating facility,[20] which frequently was a manufacturer or food processor. About half of the nonutility generated electricity was produced by burning of fossil fuels; the other half was generated by wood, waste and water, geothermal and wind power.

The state's oldest nuclear reactor, San Onofre Unit 1 owned by Southern California Edison Co. (80%) and San Diego Gas and Electric Co. (20%), was shut down in 1992 after 25 years of service. The 436 MWe reactor worked at more than 70% efficiency for its first 11 years of operation, but since 1980 was inoperative for extended periods as it was retrofitted to meet new seismic and safety standards mandated by the Nuclear Regulatory Commission.[21] Additional costs to keep it on line were estimated in 1991 to be between $250 and $750 million. As a consequence it was decided that it was more cost effective to close it and purchase the power out-of-state if necessary. The California Public Utilities Commission ruled that the two utilities owning it would be able to continue to recover the unrecouped portion of their investment in the plant through the rate base.

S. David Freeman, the former general manager of the Sacramento Municipal Utility District (SMUD), is planning to replace the power from the Rancho Seco nuclear plant (916 MW) closed in 1989 with a small cogenerating plant using natural gas, a 50 MW wind farm and a basket of small

projects promoting energy conservation, e.g. massive tree planting in an effort to cool houses.[22] In the meantime, the utility is purchasing power.

Alternate Sources of Electricity

Geothermal

Geothermal resources are often categorized as a renewable source of energy by analysts. This categorization is one of convenience since in fact geothermal steam and hot water at depth are depletable resources just as oil and gas. The reality of that has been brought home forcibly in California where production at The Geysers, the world's largest geothermal field, has been in steep decline after 20 years of steady growth. To a degree the decline in electrical production at The Geysers was slowed by changes in field production and injection practices in 1992; however it is anticipated to continue. Taking all of California's geothermal fields into account activity (Table 9) was at 1991 levels.

Table 9

Principal Geothermal installations in California (1992)[11]

Field	Gross installed capacity (MWe)		Steam/fluid production (billions of kilograms)	
	1991	1992	1991	1992
Coso Hot Springs	260	260	46.6	41.2
East Mesa	130	130	91.9	97.6
The Geysers	1900	1900	89.7	88.5
Heber	52	52	29.2	29.5
Mono-Long Valley	40	40	24.5	24.6
Salton Sea	240	240	77.7	78.0
Wendell-Amedee	3	3	8.2	8.5
Total	2625	2625		

Solar electricity

The use of solar energy in the state is principally to produce hot water in residential and commercial applications. Most of these installations are unmonitored as are small photo voltaic generators, and their collective contribution to the State's energy balance is largely unknown.

All solar electrical installations of any size, e.g. >100 MW, in the U.S. are experimental in nature. Noteworthy are KJC Operating Company's five small solar thermal electric power plants at Kramer Junction, Mojave Desert. These plants, collectively rated at 150 MW, focus the sun's direct radiation with long, trough-like mirrors or "parabolic troughs" which carry pipes with heat

absorbing fluid. In 1992 they registered a 25% diminution of normal radiation due to the eruption of Mt. Pinatubo in the Philippines in June 1991 and to an increased local cloud-cover.[23]

There are several experimental solar installations under development by the utilities in the state and others have been announced. For example, a Davis, CA group including the Pacific Gas and Electric Company has established a test site to demonstrate the potential for utility-scale applications of photo voltaics. The project calls for building a 200-500 MW solar electric system.[24]

Windpower

California's windpower industry represents 95% of the installed capacity in the U.S. and about 70% of the world's windpower generating capacity.[25] In 1992 wind installations produced 2.7 billion kilowatt hours of electricity of the 213 billion kilowatt hours consumed in the state. The California Energy Commission equates the output to the annual needs of 450,000 typical California homes based on average consumption of 500 kWh per month. While this is impressive, it should be remembered in assessing this contribution to the energy demand in the state that windpower is not a steady source of supply year-round or even over a 24 hour period. Hence by itself it can not meet the daily or monthly demands of 450,000 homes. In 1992 about 11% of electricity from windpower was delivered during peak demand; about 25% "mid-peak", 46% "off peak" and 17% "super off peak".[25] Almost three-quarters of wind generated electricity is produced between May and September.

For the first time since 1983 when windpower began to play a role in the State's energy picture both installed capacity and the number of operating turbines fell from the previous year's highs (Table 10). The explanation lies in part in the expiration of long-term interim standard offer contracts with favorable rates.[25] This in turn resulted in a sharp decline in new turbine installations replacing the many that have reached their useful life span. An additional explanation for the declines is in the failure of one operator with an estimated capacity of 21 MW to report.[25]

The statewide average annual capacity factor also fell in 1992 primarily because of declines at the Altamont field, the oldest producing area in the State. Some 206 MW of old capacity there recorded only an 8% average capacity factor. The capacity factor is still considered to be a strong indicator of wind project performance. Only operating turbines are used to calculate the factor so that performance results are not skewed by non-operational capacity. For new turbines only one-half of new capacity is included on the calculation for the first quarter of operation. The theoretical annual average is upwards of 30%, and at least one installation (San Gorgonio Farms) reached 33% in 1992.[25]

In 1992 a Danish consortium (consisting primarily of Vestas-Danish Wind Technology A/S) proposed to demonstrate advances in wind technology widely used in Europe by building 20-30 100-foot windmills in the breakwater at the Cabrillo Beach fishing pier in San Pedro.[26] Local

inhabitants were not enthusiastic despite the fact that the project claimed to save 70,000 barrels of oil and eliminate 10,000 pounds of air pollutants. More important in terms of receiving a permit from the California Coastal Commission is the impact of the windmills on the brown pelicans that roost near the site. Windmills in other parts of the state have taken heavy toll of local raptors and other large birds.

Table 10
Windpower installations in California as of January 1 [25]

Location	Capacity (MW_e)				Number of turbines			
	1990	1991	1992	1993	1990	1991	1992	1993
Altamont Pass area, 45 miles east of San Francisco	659	687	704	683	6242	6524	6818	6451
San Gorgonio Pass, Riverside Co. near Palm Springs	224	229	255	263	3388	3333	3581	3646
Tehachapi Pass, Kern Co.	417	477	644	632	4414	4422	5221	4992
Carquinez Strait, Solano Co.	2	61	60	60	62	631	600	600
Pacheco Pass, San Benito Co.			16	16			167	167
TOTAL	1302	1454	1679	1655	14106	14910	16387	15856
Capacity Factor*	18	20	20	19				

*Capacity factor is defined as the ratio of actual energy output to the amount of energy a project would produce if it operated at full rated power for 24 hours per day within a given time period.

APPENDIX A

Energy balance for 1992 (Fig. 1)

SUPPLY			(10^{12} Btu)
Electrical Imports			331
Wind			9
Hydro			73
Cogenerated electricity (fuels included in oil and gas supplies below)			
Geothermal			150
Nuclear			375
Miscellaneous electricity			18
Natural gas			2132
Include: unaccounted for gas and net storage additions			70
Coal			63
Petroleum			4124
Less exports			-399
Total			6876
DISPOSITION			
Useful energy			2948
Residential/commercial		988	
Industrial		1292	
Transportation		668	
Non-energy uses			250
Rejected energy			3773
Residential/commercial		423	
Industrial		430	
Transportation		2002	
CA electric utility generation		788	
Fossil fuels	403		
Nuclear	255		
Hydro	7		
Geothermal	123		
Out-of-state elec. generation and transmission losses		130	
Cogeneration (included in industrial)			-94
Total			6877

APPENDIX B

Data Sources for California Energy Supply (1992)

Production	Source
Crude Oil including Federal Offshore and Lease Condensate	Ref. 11.
Associated and Non associated Natural Gas (marketed, dry)	Ref. 27, Table 48, Summary Statistics for Natural Gas - California.
Electric Utility Fuel Data	Ref. 28, Table 19, Consumption of Petroleum to Produce Electricity; Ref. 27, Table 48.
Electrical Generation Oil, gas, hydro, nuclear,	Ref. 28, Tables 13, Net Generation from Electric Utilities by energy source
Wind	Ref. 25.
Cogeneration	Andrea Gough, California Energy Commission, personal communication, March 1, 1994..
Imports	
Natural Gas	
Foreign	Ref. 27, Table 9.
Domestic	Ref. 27, Table 48.
Crude Oil Foreign and Domestic	Ref. 29, Table 1-A, California Petroleum Summary.
Oil Products Foreign and Domestic	Ref. 29, Table A-1, California Fuels Market Petroleum Activity.
Coal	Ref. 30, Table 46, Coal Consumption by Census Division and State.
Electrical Power	
Net Exchange	Andrea Gough, California Energy Commission, personal communication, March 1, 1994.
Coal	Ibid.
Exports	
Oil Products Foreign and Domestic (not including bunkering fuel supplied at California ports)	Ref. 29, Table A-1.

APPENDIX C

Data Sources for California End Uses (1992)

Net Storage	
Natural Gas	Ref. 27, Table 48.
Unaccounted for Natural Gas	Ref. 27, Table 48.
Transportation	
Crude Oil	
Gasoline, Aviation and Jet fuels	Ref. 29, Table 1-A.
Taxable Diesel Fuel (for public highways)	Ref. 31, Table 4, Sales for Transportation Use: Distillate Fuel Oil End Use, 1991.
Vessel Bunkering (includes international bunkering)	Ref. 31, Table 4 & 5.
Rail Diesel	Ref. 31. Table 4.
Military Use	Ibid.
Natural Gas	
Pipeline fuel	Ref. 27, Table 48.
Industrial, Government, Agriculture, etc.	
Natural Gas (includes lease and plant fuel)	Ref. 27, Table 48.
Coal	Ref. 30, Table 24.
Electricity	Ref. 28, Table 26 Sales of Electricity to Ultimate Consumers by Class of Service, Year to date.
Crude Oil	By Difference.
Non Energy Applications	
Crude Oil and LPG	
Asphalt	Ref. 32
Petrochemical Feedstock	Ref. 33, Table 45 (estimate) & Ref. 34, Table 12
Waxes, Lubricating oils, Medicinal uses, Cleaning	Quarterly Oil Reports 1992

Residential and Small Commercial	
Natural Gas	Ref. 27, Table 48.
Crude Oil and Other Oils (kerosene, residual, and distillate)	Ref. 31, Table 6, Sales of Kerosene by End Use; Table 5, Sales of Residual Fuel Oil by End Use; Table 4, Sales of Distillate Fuel Oil by End Use.
LPG	Ref. 33, Tables 43 & 44 & Ref. 34, Table 12.
Miscellaneous "Off highway" Diesel	Ref. 31, Table 4.
Electricity	Ref. 28, Table 26

APPENDIX D

Conversion Units

Energy Source	Conversion factor, 10^6 Btu
Electricity	3.415 per million Wh
Coal 22.6 per short ton	
Natural Gas	1.05 per Mcf
Crude Oil	5.80 per barrel
Fuel Oil	
Residual	6.287 per barrel
Distillate, including diesel	5.825 per barrel
Gasoline and Aviation Fuel	5.248 per barrel
Kerosene	5.67 per barrel
Asphalt	6.636 per barrel
Road Oil	6.636 per barrel
Synthetic Rubber and Miscellaneous	
LPG Products	4.01 per barrel

Assumed Conversion Efficiencies of Primary Energy Supply

Electric Power Generation	
Hydro Power	90%
Coal	30%
Geothermal	18%
Oil and Gas	33%
Uranium	32%
Transportation Use	25%
Residential/Commercial Use	70%
Industrial Use	75%

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